**Fluids**

**Background knowledge**

**Fluid compartments**

<table>
<thead>
<tr>
<th>INTRAVASCULAR</th>
<th>INTERSTITIAL</th>
<th>INTRACELLULAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>5L (1/9)</td>
<td>9L (2/9)</td>
<td>28L (2/3)</td>
</tr>
</tbody>
</table>

Normal maintenance requirements if NBM

Depend on patient’s weight...

- **H₂O**: 1.5ml/kg/h (-2.5L)
- **Na⁺**: 1-2mmol/kg/24h (-70-140mmol)
- **K⁺**: 0.5-1mmol/kg/24h (-35-70mmol)

NB. urine output should be >0.5ml/kg/h.

**Contents of available fluids**

<table>
<thead>
<tr>
<th></th>
<th>Na⁺</th>
<th>Cl⁻</th>
<th>K⁺</th>
<th>(HCO₃⁻)</th>
<th>(glucose)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NORMAL PLASMA</td>
<td>135-145</td>
<td>100-110</td>
<td>3.5-5.0</td>
<td>22-26</td>
<td>3.5-7.8</td>
</tr>
<tr>
<td>Sodium chloride 0.9%</td>
<td>154</td>
<td>154</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hartmann’s solution</td>
<td>131</td>
<td>111</td>
<td>5</td>
<td>29</td>
<td>-</td>
</tr>
<tr>
<td>5% Dextrose</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>50g</td>
</tr>
<tr>
<td>Dextrose-saline 4%/0.18%</td>
<td>30</td>
<td>30</td>
<td>-</td>
<td>-</td>
<td>40g</td>
</tr>
<tr>
<td>Gelofusine</td>
<td>154</td>
<td>120</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**Hartmann’s solution**: Hartmann’s solution is the most physiological (i.e. similar to plasma) meaning it is very good for replacing plasma loss e.g. during surgery or GI losses. However, this does not mean it is good for normal maintenance fluids alone as 3L Hartmann’s solution over 24 hours would give 3 times too much sodium and not enough potassium.

**Normal saline**: Saline is much more physiological than dextrose as it contains salts, but is not as physiological as Hartmann’s solution. Also, be warned, too much chloride will give a hyperchloraemic acidosis (HCl ↔ H⁺ + Cl⁻) and also causes renal vasoconstriction. Too much sodium places a massive load on the kidneys.

**5% dextrose**: 5% dextrose is given instead of pure water (the glucose is used up) to maintain initial osmolarity. The glucose content plays no role whatsoever (the calorific content is negligible). It is used for maintenance to give water when needed with no electrolytes. It has no place for replacing plasma/blood loss because it is not physiological. Too much too quickly can cause hyponatraemia.

**Dextrose-saline**: Dextrose-saline contains some dextrose and some sodium chloride. It is a good solution for maintenance fluids because, given at the correct rate for the patient’s weight, it contains approximately the correct requirements of sodium. It has no place for replacing plasma/blood loss because it is not physiological. Too much too quickly can cause hyponatraemia.

**Colloids**: Colloids are given when you need to keep fluid in intravascular space. They contain large molecules which stay intravascular and create an osmotic gradient. However, they are not as inert as crystalloids and can have side effects such as anaphalaxis and renal failure. NICE do not routinely recommend their use for anything. Types include starches (valvuven/volylyte), gelatins (gelofusine), albumins.

**There are pre-made versions of saline, dextrose and dextrose saline with different concentrations of potassium (20mmol or 40mmol)**.

Note: fluids are given intravenously and, hence, are added to the intravascular space. However, depending on the osmotic gradient that they create intravascularly (colloids>saline>Hartmanns>dex-saline>dextrose), a certain proportion of the water content will be distributed across all of the fluid compartments (intravascular, interstitial, intracellular).

**Choosing a fluid regime**

**Overall requirements = maintenance fluids + replacement of fluid loss**

Prescribing fluids is not an exact science - most of the time it is the best guess for the patient’s weight/approximate quantity of lost fluid. However, you should think of each component of the above formula completely separately because the types and volumes of the fluids required will be different for each component. You should be clear what type of fluid, and how much of each type, you are giving for each component of the formula and why. The type and quantity of maintenance fluids (if needed) are based on the patient’s fluid and electrolyte requirements (dependant on their weight), and the type and quantity of replacement fluids are based on the type and quantity of fluid lost. To decide on your final prescription, you must calculate how much maintenance you need depending on requirements PLUS what and how much you need to give to replace the fluid losses.
Maintenance fluids
NB. only give maintenance fluids if the patient can’t drink enough. Oral/NG-tube fluids are safer because they are much less likely to cause salt/fluid overload, electrolyte abnormalities and do not require a cannula (infection risk).
Fluid type does not matter as long as, over 24 hours, it approximately matches the normal requirements for their weight in terms of water, sodium and potassium. Calculate how much water, sodium and potassium they need over 24 hours and choose fluids which, overall, match these requirements closest. The timing doesn’t matter but conventionally bags are given over multiples of 2 hours. Dextrose-saline is becoming preferred for maintenance fluids because it delivers the daily sodium requirement over the course of the regime rather than all in one bag.

NB. the traditional regime = “1 salty + 2 sweet”:
- 1L saline 0.9% + 20mmol potassium chloride (over 8 hours)
- 1L dextrose 5% + 20mmol potassium chloride (over 8 hours)
- 1L dextrose 5% + 20mmol potassium chloride (over 8 hours)

This gives 3L H₂O, 154mmol Na⁺ and 60mmol K⁺. This is only acceptable for a very large patient because it provides about 0.5L more water and more sodium than is required for an average patient. The fluids you give should always reflect the patient’s weight. E.g. for a 70kg patient there are many possible maintenance regimes (to match approx: 2.5L fluid, 70-140mmol Na⁺ and 35-70mmol K⁺). Examples:
- 1L dextrose-saline with 20mmol K⁺ (over 10 hours) + 1L dextrose-saline with 20mmol K⁺ (over 10 hours) + 500ml dextrose-saline (over 4 hours)
- 500ml saline 0.9% (over 6 hours) with 20mmol K⁺ + 1L dextrose 5% with 20mmol K⁺ (over 10 hours) + 1L dextrose 5% with 20mmol K⁺ (over 8 hours)
- 1L Hartmann’s (over 10 hours) + 1L 5% dextrose (over 8 hours) with 40mmol K⁺ + 500ml 5% dextrose (over 6 hours) with 20mmol K⁺

If a patient is drinking some fluids, but not enough, determine their fluid intake and top it up with IV/NG fluids. Regardless, ensure you always check the U&Es before prescribing any fluids and adjust the regime as necessary for any electrolyte abnormalities.

Replacement of fluid loss
Includes two components:
1. Pre-existing fluid deficit (replaced STAT)
2. Ongoing losses (replace future losses as they occur)

The type of fluid replacement depends on the type of fluid lost i.e. fluid loss should be replaced by fluids with a similar electrolyte content to the lost fluid. DO NOT use maintenance regimens to correct plasma or blood loss because you can cause a dangerous hyponatraemia.

Types of fluid lost and what they should be replaced with include:
- Extracellular fluid (e.g. D&V, NG aspirates, stomas, burns, pancreatitis): should be replaced by a fluid similar to extracellular fluid – which is similar to plasma (e.g. Hartmann’s solution, or saline if Hartmann’s solution not available). But note, if a patient needs a lot of sodium-rich fluid resus, Hartmann’s solution is preferred to normal saline because it contains less chloride (too much chloride causes a hyperchloremic acidosis).
- Normal dehydration (e.g. pyrexia, poor intake): should be replaced by normal maintenance fluids (e.g. dextrose-saline).
- Blood: should be replaced with blood. If the patient continues to bleed, they may also need other products e.g. FFP, platelets to actually stop the bleeding rather than replace the lost red cells.

Pre-existing fluid/electrolyte deficit
Decide on the approximate deficit and the cause by:
- History
- Observations
- Hydration status examination
- Fluid balance chart (input, catheter output etc)
- U&Es (but be aware this is a measurement of the plasma U&Es, and may not represent the whole body stores because the body compensates to keep the blood levels within a certain range)

The quantity of fluid replacement depends on your estimate of the fluid deficit.

Fluid resus to replace pre-existing deficits is done in STAT boluses. You must prescribe a bolus and then reassess the patient’s urine output and blood pressure after the bolus to guide further fluid resus. E.g. if an patient has been vomiting 2L/day for 2 days and not drinking, they are likely to be depleted around 4L across all compartments. A bolus of 1-2L Hartmann’s solution stat (then a reassessment) would be the best course of action.

<table>
<thead>
<tr>
<th>Shock class</th>
<th>Fluid lost</th>
<th>Signs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.75L</td>
<td>Minimal, mild tachycardia</td>
</tr>
<tr>
<td>2</td>
<td>0.75-1.5L</td>
<td>Moderate tachycardia and hypotension</td>
</tr>
<tr>
<td>3</td>
<td>1.5-2L</td>
<td>Severe tachycardia and hypotension, confusion</td>
</tr>
<tr>
<td>4</td>
<td>&gt;2L</td>
<td>Critical tachycardia and hypotension</td>
</tr>
</tbody>
</table>

Ongoing losses
You must estimate these and aim to prescribe a regime to replace these future losses as they occur with a type of fluid with a similar electrolyte consistency to the fluid lost.

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Managing acutely hypotensive patients

**Fluid challenge for hypotensive patients**

For acutely hypotensive patients when you are unsure of the exact cause, fluid challenge with 250-500ml crystalloid over 5 minutes. Monitor response by BP, UO and JVP:

- Respond fully = just give maintenance fluids
- Respond and fall again = more fluids (adequate resus depends on patient but usually around 20ml/kg quickly)
- No response = patient is either fluid overloaded (don’t give any more fluids) or very depleted (give lots of fluids) - assess clinically

**WARNING:** take care if heart failure history/signs (use only 250ml fluid challenge and be wary of giving any more)

What to replace losses with if they need more fluids:
- Replace plasma loss with physiological fluids (i.e. Hartmann’s solution)
- Replace blood with blood

**Special situations**

**Post-operatively**

K⁺ is intracellular and levels can increase due to cell lysis during surgery. Hence, if K⁺ is over 4.5mmol/L, omit it for 24 hours. If K⁺ is normal/low, you can give some e.g. 40mmol/24h.

Some centres advise to avoid using normal saline after surgery because of the endocrinological sodium retention mechanisms triggered by surgery and sodium containing substances commonly used in theatre (colloids, Hartmann’s solution, IV antibiotics). Too much sodium chloride can result in oedema, hyperchloraemic acidosis, increased kidney load, increased post-op complications and GI problems. These centres often advise the use of dextrose-saline (contains less sodium chloride). Only give fluids if they actually need them!

**Sepsis**

Sepsis causes intravascular depletion due to plasma loss because of leaky capillaries and vasodilation. Replace fluid with crystalloid e.g. Hartmann’s, but avoid too much sodium and chloride e.g. lots of bags of saline (for reasons above). Be wary they may need inotropes in intensive care to maintain blood pressure and reduce peripheral fluid losses.

**Heart failure**

Heart failure patients are prone to fluid overload and pulmonary oedema. Be attentive to their fluid balance. Requirements depend on severity but usually no more than 2L/24 hours. If overload develops: fluid restriction/furosemide, low sodium diet and daily weights (there is no logic in giving furosemide along with fluids). **Note** if a patient has a low SBP and a low urine output who is at risk of LVF, you **must** examine the patient because there are two opposite causes for this clinical picture:

1. Dehydration: they may simply be fluid deplete (treatment = fluids)
2. LVF and overload: they may be in LVF which causes a low SBP and hence a low urine output (treatment = furosemide which will improve LVF and hence paradoxically increase SBP and urine output)

**Liver failure**

Excess Na⁺ may cause ascites so ONLY use 5% dextrose.

**Acute renal failure**

Avoid K⁺.

**Chronic renal failure**

Avoid excess fluids, sodium and potassium (kidneys can’t excrete). Avoid Hartmanns because it contains lactate.

**Extravasation of plasma (e.g. in sepsis)**

Prescribe fluids which will maintain the intravascular volume e.g. Hartmann’s solution or colloids. These patients may need inotropic support.

**Alcoholic**

MUST give Pabrinex before giving any 5% dextrose (even if hypoglycaemic). It can precipitate Korsakoff syndrome.

**Brain haemorrhage**

Avoid dextrose (causes osmotic haematoma swelling) – Dextrose Destroys the brain if there’s a bleed!

Saline is best.

**Risk of re-feeding syndrome**

Avoid dextrose where possible because it can precipitate re-feeding syndrome.

**Electrolyte imbalances**

See notes on U&Es interpretation.